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# Technical Requirements for Construction Materials Testing

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U. S. DEPARTMENT OF COMMERCE
Technology Administration
National Institute of Standards
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Gaithersburg, MD 20899

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**June 25, 2003**

**U.S. DEPARTMENT OF COMMERCE**
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**NATIONAL INSTITUTE OF STANDARDS AND TECHNOLOGY**
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# Technical Requirements For Construction Materials Testing

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## INTRODUCTION

This document describes accreditation requirements for laboratories operating in the Construction Materials Testing (CMT) field. It was prepared by the Construction Materials Testing Subcommittee of the National Association for Laboratory Accreditation Cooperation (NACLA) Technical Requirements Committee and reflects requirements established by the Federal Highway Administration, Federal Aviation Administration, United States Army Corps of Engineers, and the Bureau of Reclamation to meet their needs for competent construction materials services.

NACLA CMT Subcommittee members include both government and private sector representatives: Michael Rafalowski, Federal Highway Administration; David Cross, Federal Aviation Administration; Bradley James, United States Army Corps of Engineers; Tim Dolen, Bureau of Reclamation; Keith Lane, Connecticut Department of Transportation; Warren Merkel, American Association for Laboratory Accreditation; Peter Spellerberg, American Association of State Highway and Transportation Officials (AASHTO) Materials Reference Laboratory; Patrick McCullen, International Accreditation Service Inc.; Carroll Brickenkamp, National Voluntary Laboratory Accreditation Program; Richard Kistner, American Council of Independent Laboratories; and Mary Jo DiBernardo, National Institute of Standards and Technology (NIST).

NIST is publishing this document as a public service pursuant to the Institute's responsibilities under the National Technology Transfer and Advancement Act of 1995, which directed NIST to "coordinate Federal, State, and local technical standards activities and conformity assessment activities, with private sector technical standards activities and conformity assessment activities, with the goal of eliminating unnecessary duplication and complexity in the development and promulgation of conformity assessment requirements and measures."

Internationally accepted criteria for the operation of accreditation bodies and accreditation of laboratories - ISO/IEC Guide 58, *Calibration and Testing Laboratory Accreditation Systems – General Requirements for Operation and Recognition* and ISO/IEC 17025 *General Requirements for the Competence of Testing and Calibration Laboratories* - and guidance documents developed by the American Society of Testing and Materials International Corporation (ASTM) committees form the basis for this document. The document contains additional requirements to both ISO/IEC Guide 58 and ISO/IEC 17025 specific to the CMT field as stipulated to meet U.S. Federal agency requirements. Technical requirements contained herein are related to the AASHTO document R18, "Recommended Practice for Establishing and Implementing a Quality System for Construction Materials Testing Laboratories."

This document is organized such that paragraph numbering is in line with the paragraphs (sections and subsections) of ISO/IEC 17025.

## PURPOSE

The purpose of this document is to define the process for third-party accreditation of testing laboratories and to specify the minimum criteria for those accreditations to meet requirements of the Federal Highway Administration, Federal Aviation Administration, United States Army Corps of Engineers, and the Bureau of Reclamation. This manual is not intended as a restatement of ISO/IEC 17025. In addition, there are also additional requirements for two elements of ISO/IEC Guide 58.

The additions, or modifications, or where clarifications are considered necessary, are only listed. Table I provides quick reference to those sections for which additional requirements are listed.

Accreditation is defined in ISO/IEC Guide 2 as the formal recognition that a laboratory is competent to carry out specific types of tasks. "Formal recognition" comes about as the result of a full laboratory assessment. Assessment includes quality system and documentation review as well as on-site assessment of technical competence. Accreditation is granted for the specific tests/calibrations that are documented in the Scope section of the Letter of Accreditation.

For the purposes of this document an accredited laboratory is one that complies with ISO/IEC 17025 and the additional requirements of this document. Compliance is determined by the results of assessment and documented in the Letter of Accreditation from a recognized accrediting body.

SCOPE

Accreditation is defined in ISO/IEC Guide 2 as the formal recognition that a laboratory is competent to carry out specific types of tasks. "Formal recognition" comes about as a result of a full laboratory assessment. Assessment includes quality system and documentation review as well as on-site assessment of technical competence. Accreditation is granted for the specific tests/calibrations that are documented in the Scope section of a Letter of Accreditation issued by an independent third party.

The scope of the CMT field, as described in this document, includes the following materials areas: concrete and aggregates, cement, soils, bituminous materials, roofing materials, masonry, steel, and non-destructive tests related to construction. Accreditation may be offered for one or more tests in each area. Additional areas may be added upon request. As an option, a laboratory may also obtain accreditation for one or more of the following construction materials engineering standards:

| | |
|---|---|
| ASTM E329 | Specification for Agencies Engaged in the Testing and/or Inspection of Materials Used in Construction |
| ASTM C1077 | Practice for Laboratories Testing Concrete and Concrete Aggregates for Use in Construction and Criteria for Laboratory Evaluation |
| ASTM D3666 | Specification for Minimum Requirements for Agencies Testing and Inspecting Bituminous Paving Materials |
| ASTM D3740 | Practice for Evaluation of Agencies Engaged in Testing and/or Inspection of Soils and Rock as Used in Engineering Design and Construction |
| ASTM C1093 | Practice for Accreditation of Testing Agencies for Unit Masonry |
| ASTM E1212 | Practice for Establishment and Maintenance of Quality Control Systems for Nondestructive Testing Agencies |
| ASTM E543 | Practice for Evaluating Agencies that Perform Nondestructive Testing |
| ASTM A880 | Practice for Criteria for Use in Evaluation of Testing Laboratories and Organizations for Examination and Inspection of Steel, Stainless Steel and Related Alloys |

When accredited for one of these engineering standards, the laboratory's scope of accreditation shall indicate "Construction Materials Testing".

## Table 1. "Clauses with Additional Requirements"

| Clause | Topic |
|---|---|
| **ISO/IEC Guide 58** | |
| 4.3.2 | Quality Manual |
| 6.2 | Assessment |
| 6.7.2 | Surveillance and Reassessment of Accredited Laboratories |
| **ISO/IEC 17025** | |
| 4.1 | Organization |
| 4.2.1 | The Quality Manual |
| 4.12 | Control of Records |
| 4.14 | Management Reviews |
| 5.2 | Personnel |
| 5.5 | Equipment |
| 5.9 | Assuring the Quality of Test and Calibration Results |
| 5.10.1 | Reporting Results |

**Additional Requirements to ISO Guide 58 for Accreditation Bodies**

This section defines both general and specific requirements for the application of the ISO/IEC Guide 58 to accreditation bodies in the CMT field.

The Accreditation Body in developing and implementing its accreditation program shall follow the requirements in the NACLA Recognition Document and ISO/IEC Guide 58. In addition, the following requirements shall also apply.

4.3.2 Quality Manual

The Accreditation Body shall, as a minimum, hold annual meetings with all assessors in the appropriate construction/test area to discuss complaints, inconsistencies in assessments, changes in procedures, etc.

6.2 Assessment

The assessor shall verify that the laboratory has the appropriate equipment, calibration and verification records, test procedures, and trained personnel to perform every procedure in the proposed scope.

The assessor shall observe a complete demonstration of each test on the scope that appears on the list of test procedures listed in Appendix B. The assessor shall use checklists to record all findings. Test procedures shall be performed with applicable materials.

The assessor shall observe a sampling of all test procedures from areas not covered by test procedures listed in Appendix B. For those tests not listed in Appendix B, the assessor must also observe a complete demonstration of at least 25% of the tests within a particular discipline. The assessor shall use checklists to record all findings.

The accreditation body shall verify that the laboratories' testing equipment used in the test procedures listed in Appendix B meet the standards. The accreditation body shall either own all the appropriate equipment for this verification or have a third party provide the equipment. A recommended list of equipment that can be used for verification is contained in Appendix C. The assessor has the option of either verifying the test equipment him/herself or observing laboratory personnel verify the test equipment with the equipment that is owned or controlled by the accreditation body. This program shall ensure that the measurements made are traceable to the International System of Units (SI) or if appropriate a consensus standard.

6.7.2 Surveillance and Reassessment of Accredited Laboratories

The accreditation body shall evaluate a laboratory's status at least annually. The annual evaluation shall, at a minimum, take into consideration the laboratory's performance in proficiency testing programs.

**Additional Requirements to ISO/IEC 17025 for Laboratories**

This section defines both general and specific requirements in addition to those contained in ISO/IEC 17025. Paragraph numbering is aligned with 17025. As a minimum, it is expected that all requirements of 17025 be satisfied, with the exception of clauses that can be justified, and documented, as "Not Applicable" to a particular laboratory.

The requirements for the CMT field are based on the applicable requirements of the specific standards for which accreditation is sought. The requirements of AASHTO R18, *Establishing and Implementing a Quality System for Construction Materials Testing Laboratories,* were considered in developing this document.

Each of the following statements should be understood to be mandatory laboratory requirements.

**4 Management Requirements**

**4.1 Organization**

4.1 Operational position descriptions shall identify the position and include a description of the duties associated with the position, required skills, education and experience, and supervision exercised and received.

**4.2 Quality System**

4.2.1a The quality manual or related documentation shall contain a brief biographical sketch, noting the education, work experience, licensure, certifications, and current position of supervisory technical staff involved in testing areas included in the scope of accreditation.

**4.12.2 Technical Records**

4.12.2.1a The laboratory shall retain results of participation in proficiency sample programs including data sheets, summary reports, and documentation describing steps taken to determine the cause of outlying results and the corrective actions taken.

4.12.2.1b Records pertaining to testing, equipment calibration and verification, test reports, Internal audits and management reviews, proficiency sample testing, test Technician training and evaluation, and personnel shall be retained by the laboratory in a secure location for a minimum of three (3) years.

4.12.2.1c The laboratory shall maintain calibration and verification records for all

equipment used for the correct performance of the tests on the scope of accreditation. Such records shall include:

a) detailed results of the work performed (dimensions, mass, force, frequency, temperature, time, etc.)
b) description of the equipment calibrated or verified including model and serial number or other acceptable identification
c) date the work was done
d) identification of the individual performing the work
e) identification of the calibration or verification procedure used
f) the previous calibration or verification date, the next due date, and the identification of any in-house calibration or verification device used (including serial numbers, lab numbers or other identification used to establish traceability of items such as standard masses, proving rings, standard thermometers, balances, calipers, etc.)

**4.14 Management Reviews**

4.14 The laboratory's management shall review the quality system established to satisfy the requirements of this standard at least annually. In addition, the laboratory shall also have a policy to perform a management review when there is a reason to suspect problems in the quality of the CMT work, such as technical complaints, proficiency testing results, etc.

**5. Technical Requirements**

**5.2 Personnel**

5.2.2a The training procedure shall indicate what position(s) or employee(s) is responsible for the laboratory's training program and maintenance of training records, shall describe the distribution of records to management and, shall identify the location of resulting records.

5.2.2b The training procedure shall also describe the method(s) used to evaluate staff competency to ensure that each test covered by the scope of accreditation is performed in accordance with standard procedures. This description shall include the frequency of evaluations for each technician and indicate what position(s) or employee(s) is responsible for evaluating staff competency and maintaining records, shall describe the distribution of records to management and shall identify the location of resulting records. The procedure shall ensure that each technician performing each test method is evaluated.

5.2.2c Training records shall include a form for recording training and competency evaluation activities summarized under 5.2.2 including the name of the trainee, name of the evaluator, test method evaluated, the dates, and results.

**5.5 Equipment**

5.5.5a The laboratory's records shall include a list(s) giving a general description of equipment for performing the test methods on the scope of accreditation which require calibration or verification, a reference to the calibration or verification procedure used, and the location of the calibration or verification records.

5.5.5b The test equipment listed in Tables 2-6 Appendix A shall be calibrated or verified at intervals no greater than those shown in those Tables unless the laboratory has documentation that a different calibration/verification interval is appropriate.

5.5.5c Each piece of equipment shall be labeled to identify the specific calibration due date or usage equivalent.

5.5.6 The laboratory shall have detailed written procedures for all in-house calibration and verification activities not addressed in standards. These procedures shall indicate the equipment required to perform the calibration or verification.

**5.9 Assuring the Quality of Test and Calibration Results**

5.9a Proficiency Testing

Applicants under Construction Materials Testing are required to participate in all the available proficiency testing programs for the tests included in their scope of accreditation. Enrollment in the following programs related to a laboratory's scope of accreditation satisfies this requirement.

Proficiency Sample Programs of the Cement and Concrete Reference Laboratory
(For further information, call 301-975-6704.)

A. Concrete Applicable Standards: ASTM C39, C138, C143, C173, and C192.

B. Cement Applicable Standards: ASTM C109, C114, C115, C151, C185, C186, C187, C188, C191, C204, C266, C430, and C451.

C. Masonry Applicable Standards: ASTM C91, C109, C151, C185, C187, C188, and C266.

Proficiency Sample Programs of the AASHTO Materials Reference Laboratory
(For further information, call 301-975-6704.)
(AASHTO equivalent standards are in parentheses after each ASTM designation)

D. Bituminous — Applicable Standards: ASTM D5 (AASHTO T49), D70 (T228), D92 (T48), D1754 (T179), D2042 (T44), D2170 (T201) D2171 (T202), D2872 (T240).

E. Soils — Applicable Standards: ASTM D422 (AASHTO T88), D698 (T99), D854 (T100), D2844 (T190), D4318 (T89 & T90).

F. Aggregate — Applicable Standards: ASTM C88 (AASHTO T104), C117 (T11), C127 (T85), C128 (T84), C131 (T96), C136 (T27).

G. Bituminous Concrete — Applicable Standards: ASTM D5 (AASHTO T49), D1559 (T245), D1560 (T246), D1856 (T170), D2041 (T209), D2170 (T201), D2171 (T202), D2172 (T164), D2726 (T166), D3203 (T269), D5444 (T30).

5.9b If a laboratory's results are deemed outliers or unacceptable (ratings of "0" or "1" for the above programs), then the laboratory shall promptly investigate and determine the cause(s) for such unacceptable results, correct any problems identified, and report to AB.

**5.10 Reporting Results**

**5.10.1 General**

5.10.1 The laboratory shall have a procedure that describes methods used to prepare, check and amend test reports. The procedure shall identify the individual(s) responsible for maintaining test reports, shall describe the distribution of test reports, and shall identify the location of stored test reports.

## Appendix A: Equipment Calibration and Verification Intervals

### TABLE 2 Bituminous Materials Test Equipment

| Equipment—Test Method | Requirement | Interval (Month) |
|---|---|---|
| Saybolt Viscometers—T 59, D 244 | Calibrate | 36 |
| Mechanical Shakers | Ck. Sieving Thoroughness | 12 |
| Gen. Purpose Balances, Scales & Weights | Verify | 12 |
| Test Thermometers—T 201, T 202, T 209, T 228 T 49, T 51, T 295, D 5, D 70, D 113, D 2041, D 2170, D2171, D 3142 | Calibrate | 6 |
| Analytical Balances & Weights | Verify | 24 |
| Comp. Test. Mach.—T 165, T 167, T 245, T 246, D 1074, D 1075, D 1959, D 1560 | Verify Load Indications | 12 |
| Mechanical Compactor—T 245, D 1559 | Calibrate | 36 |
| CA Kneading Compactor—T 247, D 1561 | Calibrate | 24 |
| Timers—T 201, T 202, D 2170, D 2171 | Ck. Accuracy | 6 |
| Ovens | Verify Temp. Settings | 4 |
| Penetrometer and Accessories—T 49, D 5 | Ck. Dial & Timer Acc. & Needle Cond. | 6 |
| Ductility Machine—T 51, D 113 | Ck Molds & Speed of Travel | 12 |
| TFO & RTFO Oven—T 179, T 240, D 1754, D 2872 | Shelf/Carriage Ck. Rotation Speed & Temp. | 12 |
| Vacuum System—T 209, D 2041 | Ck. Pressure | 12 |
| Sieves | Coarse (≥ 4.75mm): Ck. Openings & Physical Condition<br>Fine (< 4.75 mm): Ck. Physical Condition | 6 |
| Molds, Followers, Calib Cylinders—T 246, T 247 D 1560, D 1561 | Ck. Critical Dimensions | 12 |
| Molds, Manual Comp. Hammers, Breaking Heads—T 245, D 1559 | Ck. Critical Dimensions & Mass of Hammer | 12 |
| Molds & Plungers —T 167, D 1074 | Ck. Critical Dimensions | 12 |
| Brass Rings & Assembly —T 53, D 36 | Ck. Critical Dimensions | 12 |
| Pycnometers—T 228, D 70 | Ck. Critical Dimensions & Phys. Cond. | 12 |
| Collars & Floats—T 50, D 139 | Ck. Critical Dimensions | 12 |
| Flowmeters—T 170, T 240, D 1856, D 2872 | Calibrate | 12 |
| Flash Cups—T 48, T 79, D 92, D 3143 | Ck. Critical Dimensions | 12 |

**TABLE 3 Soils Test Equipment**

| Equipment—Test Method | Requirement | Interval (Month) |
|---|---|---|
| Mechanical Shakers | Ck. Sieving Thoroughness | 12 |
| Gen. Purpose Balances, Scales & Weights | Verify | 12 |
| Compression or Loading Device—T 193, T 208, T 216, T 236, T 296, T 297, D 1883, D 2166, D 2435, D 2850, D 3080, D 4767 | Verify Load Indications | 12 |
| Mechanical Compactor—T 99, T 180, D 698, D 1557 | Calibrate | 12 |
| CA Kneading Compactor—T 190, D 2844 | Calibrate | 24 |
| Ovens | Verify Temperature Setting(s) | 4 |
| Vacuum System—T 100, D 854 | Ck. Pressure | 24 |
| Molds—T 99, T 134, T 135, T 136, T 180, T 190, T 193, D 698, D 558, D 559, D 560, D 1557, D 1883, D 2844 | Ck. Critical Dimensions | 12 |
| Manual Hammer—T 99, T 180, D 698, D 1557 | Ck. Wt. & Critical Dimensions | 12 |
| Sieves | Coarse (≥ 4.75 mm): Ck. Openings & Physical Condition<br>Fine (< 4.75 mm): Ck. Physical Condition | 6 |
| Liquid Limit Device—T 89, D 4318 | Ck. Wear & Critical Dimensions | 12 |
| Grooving Tool—T 89, D 4318 | Ck. Critical Dimensions | 12 |
| Hydrometers—T 88, D 422 | Ck. Critical Dimensions | 24 |
| Straightedge—T 99, T 134, T 135, T 136, T 180, D 698, D 558, D 559, D 560, D 1557 | Ck. Planeness of Edge | 6 |
| Weighted Foot Assembly—T 176, D 2419 | Ck. Weight | 12 |
| CBR Annular and Slotted Weights—T 193, D 1883 | Ck. Weight | 12 |
| CBR Penetration Piston—T 193, D 1883 | Ck. Diameter | 12 |
| Standard Metal Specimen—T 190, D 2884 | Ck. Outside Diameter | 12 |
| Metal Follower—T 190, D 2844 | Ck. Diameter | 12 |

**TABLE 4 Aggregate Test Equipment**

| Equipment—Test Method | Requirement | Interval (Month) |
|---|---|---|
| Unit Weight Measures—T 19, C 29 | Calibrate | 12 |
| Mechanical Shakers | Ck. Sieving Thoroughness | 12 |
| Gen. Purpose Balances, Scales & Weights | Verify | 12 |
| Sieves | Coarse (≥ 4.75 mm): Ck. Openings & Physical Condition<br>Fine (< 4.75 mm): Ck. Physical Condition | 6 |
| Ovens | Verify Temp. Settings | 4 |
| Sulfate Oven—T 104, C 88 | Ck. Rate of Evaporation | 12 |
| L.A. Machine—T 96, C 131 | Ck. RPM & Crit Dimensions | 24 |
| Conical Mold, Tamper—T 84, C 128 | Ck. Critical Dimensions | 24 |
| Steel Balls—T 96, C 131 | Ck. Indiv. Wt. & Charge Wt. | 24 |
| Sodium Sulfate Containers—T 104, C 88 | Ck Physical Condition | 12 |

**TABLE 5 Portland Cement Concrete Test Equipment**

| Equipment—Test Method | Requirement | Interval (Month) |
|---|---|---|
| Unit Weight Measures—T 121, C 138 | Calibrate | 12 |
| Air Meters—T 152, T 196, C 173 C 231 | Calibrate | 3 |
| Comp. Testing Machine—T 22, C 39 | Verify Load Indications | 12 |
| Flex. Testing Machine T97, C78, T177, C293 | Verify Load Indications | 12 |
| Capping Material | Check Strength | 3 |
| Slump Cones—T 119, C 143 | Check Critical Dimensions | 12 |
| Metallic Reusable Molds—T 22, T 23, C 31, C 39 | Check Critical Dimensions | 12 |
| Single Use Molds—T 22, T 23 C 31, C 39, C192 | Check Dimensions of Each Shipment | — |
| Moist Room/ Storage Tanks—C 31, C 39 | Temp. Verified with Recording Thermometer | — |
| Gen. Purpose Balances, Scales & Weights | Verify | 12 |

**TABLE 6 Hydraulic Cement Test Equipment**

| Equipment—Test Method | Requirement | Interval (Month) |
|---|---|---|
| Moist Cabinet/Water Task Recording Thermometer—T 106, C 109 | Check for Accuracy | 6 |
| Storage Water—T 106, C 109 | Check for Lime Saturation | 6 |
| General Purpose Balances, Scales & Weights | Verify | 12 |
| Analytical Balances & Weights | Verify | 12 |
| No. 325 Sieves—T 192, C 430 | Clean after 5 Determinations<br>Calibrate after 100 Determinations | — |
| No. 325 Nozzle—T 192, C 430 | Check Flow Rate | 6 |
| Compression Testing Machine—T 106, C 109 | Verify Load Indications | 12 |
| Bearing Blocks—T 106, C 109 | Check Planeness | 12 |
| Wagner Turbidimeter—T 98, C 115 | Calibrate | 6 |
| Standard Sand | Each new Shipment<br>Check for Conformance to C 778 | — |
| Air-Permeability Apparatus—T 153, C 204 | Standardize Using NIST 114 | 30 |
| Flow Tables—M 152, C 230 | Verify Flow Results | 30 |
| Air Content Measures—T 137, C 185 | Calibrate | 30 |
| Cube Molds and Tampers—T 106, C 109 | Ck. Crit. Dim. And Phy. Cond. | 30 |
| Vicat Apparatus and Vicat Ring—T 129, T 131, T 186, C 187, C191, C 451 | Ck. Crit Dim., Phy. Cond. and Mass | 30 |
| Gillmore Test Apparatus—T 154, C 266 | Ck. Crit. Dim., Phy. Cond. and Mass | 30 |
| Mechanical Mixing Apparatus—T 162, C 305 | Ck. Crit. Clearances and Speeds | 30 |
| Water-Retention Apparatus—C 91 | Ck. Crit. Dimensions | 30 |

**Appendix B: Test Methods Which Require Complete Demonstration**

SOIL Test Methods

| | |
|---|---|
| Dry Preparation | T87/**D421** |
| Particle-Size Analysis (Hydrometer) | T88/**D422** |
| Liquid Limit | T89/**D4318** |
| Plastic Limit | T90/**D4318** |
| Shrinkage Factors | T92/**D427** |
| Standard Proctor (5.5-lb) | T99/**D698** |
| Specific Gravity | T100/**D854** |
| Moisture-Density Soil-Cements | T134/**D558** |
| Wetting and Drying Soil-Cements | T135/**D559** |
| Freezing and Thawing Soil-Cements | T136/**D560** |
| Wet Preparation | T146/**D2217** |
| Sand Equivalent | T176/**D2419** |
| Modified Proctor (10-lb) | T180/**D1557** |
| R-Value | T190/**D2844** |
| California Bearing Ratio (CBR) | T193/**D1883** |
| Unconfined Compressive Strength | T208/**D2166** |
| Sand Permeability | T215/**D2434** |
| Consolidation | T216/**D2435** |
| Direct Shear | T236/**D3080** |
| Moisture Content | T265/**D2216** |
| Unconsolidated Undrained (UU) Triax | T296/**D2850** |
| Consolidated Undrained (CU) Triax | T297/**D4767** |
| Nuclear Gauge - Density | T310/**D2922** |
| Nuclear Gauge - Moisture Content | T310/**D3017** |
| No. 200 Wash | **D1140** |
| Classification of Soils | **D2487** |
| Description / Identification of Soils | **D2488** |
| Flexible-Wall Permeability | **D5084** |
| Density & Unit Weight by Sand Cone | **D1556** |
| Density & Unit Weight by Rubber Balloon | **D2167** |
| Calibration of Laboratory Mechanical-Rammer Soil Compactors | **D2168** |
| Description & Identification of Soils (Visual-Manual Procedure) | **D2488** |
| Density by Drive Cylinder Method | **D2937** |
| Preserving & Transporting Samples | **D4220** |
| Maximum Index Density by Vibratory Table | **D4253** |
| Minimum Index Density | **D4254** |
| One-Dimensional Swell or Settlement Potential | **D4546** |
| Density by Sleeve Method | **D4564** |
| Determination of Water Content of Soil by Microwave Oven | **D4643** |

BITUMINOUS Test Methods

| | |
|---|---|
| Solubility | T44/**D2042** |
| Cleveland Flash | T48/**D92** |
| Penetration | T49/**D5** |
| Float | T50/**D139** |
| Ductility | T51/**D113** |
| Softening Point | T53/**D36** |
| Water in Petroleum | T55/**D95** |
| Distillation of Cut-Back | T78/**D402** |
| Tag Flash | T79/**D3143** |
| Thin-Film Oven (TFO) | T179/**D1754** |
| Kinematic Viscosity | T201/**D2170** |
| Absolute Viscosity | T202/**D2171** |
| Specific Gravity | T228/**D70** |
| Rolling Thin-Film Oven (RTFO) | T240/**D2872** |
| Hydrometer | T295/**D3142** |
| Force Ductility | T300 |
| Elastic Recovery | T301 |
| Bending Beam Rheometer (BBR) | T313 |
| Direct Tension (DT) | T314 |
| Dynamic Shear Rheometer (DSR) | T315 |
| Rotational Viscosity (Brookfield) | T316/**D4402** |
| Residue of Specified Penetration | **D243** |
| Nickel Crucible | **D3289** |
| Toughness and Tenacity | **D5801** |
| Pressurized Aging Vessel (PAV) | R28 |

EMULSIFIED ASPHALT Test Methods

| | |
|---|---|
| Residue by Distillation | T59 / **D244** |
| Residue by Evaporation | T59 / **D244** |
| Particle Charge | T59 / **D244** |
| Saybolt Viscosity | T59 / **D244** |
| Demulsibility | T59 / **D244** |
| Settlement | T59 / **D244** |
| Cement Mixing | T59 / **D244** |
| Sieve Test | T59 / **D244** |
| Storage Stability | T59 / **D244** |

HOT-MIX ASPHALT Test Methods

| | |
|---|---|
| Mechanical Analysis of Extracted Aggregate | T30/**D5444** |
| Moisture or Volatile Distillates | T110/**D1461** |
| AC Content by Extraction | T164/**D2172** |
| Effect of Water on Cohesion | T165/**D1075** |
| Bulk Specific Gravity | T166/**D2726** |
| Compressive Strength | T167/**D1074** |
| Abson Recovery | T170/**D1856** |
| Max. Specific Gravity (Rice) | T209/**D2041** |
| Marshall | T245/**D1559** |
| Hveem | T246/**D1560** |
| California Kneading Compactor | T247/**D1561** |
| Percent Air Voids | T269/**D3203** |
| Paraffin Bulk Specific Gravity | T275/**D1188** |
| Resistance to Moisture (TSR) | T283/**D4867** |
| AC Content by Nuclear Method | T287/**D4125** |
| AC Content by Ignition Oven | T308/**D6307** |
| Gyratory Compactor | T312 |
| Density of Bituminous Concrete in Place by Nuclear Methods | **D2950** |
| Rotavapor Recovery | **D5404** |
| Unit Weight, Marshall Stability, and Flow of Bituminous Mixtures | CRD-C649 |
| Density and Percent Voids | CRD-C650 |

AGGREGATE Test Methods

| | |
|---|---|
| No. 200 Wash | T11/**C117** |
| Unit Weight | T19/**C29** |
| Organic Impurities | T21/**C40** |
| Sieve Analysis | T27/**C136** |
| Sieve Analysis of Mineral Filler | T37/**D546** |
| Fine Agg Specific Gravity | T84/**C128** |
| Coarse Agg Specific Gravity | T85/**C127** |
| L.A. Abrasion | T96/**C131** |
| L.A. Machine, Large Size Coarse Aggregate | T96/**C535** |
| Sulfate Soundness | T104/**C88** |
| Clay Lumps and Friable Particles | T112/**C142** |
| Lightweight Pieces | T113/**C123** |
| Sand Equivalent | T176/**D2419** |
| Aggregate Durability | T210/**D3744** |
| Reducing Field Samples | T248/**C702** |
| Moisture Content | T255/**C566** |
| Uncompacted Void Content | T304/**C1252** |
| Surface Moisture in Fine Aggregate | **C70** |
| Effects of Organic Impurities on Mortar Strength | **C87** |
| Alkali Reactivity of Cement-Aggregate Combinations (Mortar-Bar Method) | **C227** |
| Alkali-Silica Reactivity of Aggregates (Chemical Method) | **C289** |
| Petrographic Examination | **C295** |
| Effectiveness of Mineral Admixtures or GBFS on Preventing Expansion | **C441** |
| Alkali Reactivity of Carbonate Rocks (Rock Cylinder Method) | **C586** |
| Staining Materials in Lightweight Aggregates | **C641** |
| Frost Resistance by Critical Dilation Procedure | **C682** |
| Length Change Due to Alkali-Carbonate Reaction | **C1105** |
| Degradation of Fine Aggregate due to Attrition | **C1137** |
| Abrasion Resistance of Concrete (Underwater Method) | **C1138** |
| Length Change Alkali-Silica Reaction | **C1293** |
| Sampling | **D75** |
| Flat & Elongated Particles | **D4791** |
| Fractured Faces | **D5821** |
| Fineness Modulus | CRD-C104 |
| Flat & Elongated Particles | CRD-C119 |
| Scratch Hardness | CRD-C130 |
| Percentage of Crushed Particles in Aggregate | CRD-C171 |
| Scales | |

CONCRETE Test Methods

**Plastic Concrete**

| | |
|---|---|
| Bleeding of Concrete | T-158/**C232** |
| Making and Curing Concrete Test Specimens in the Field | T-23/**C31** |
| Making and Curing Concrete Test Specimens in the Laboratory | T-126/**C192** |
| Slump of Hydraulic Cement Concrete | T-119/**C143** |
| Mass per Cubic Meter (Cubic Foot), Yield, and Air Content (Gravimetric) of Concrete | T-121/**C138** |
| Sampling Freshly Mixed Concrete | T-141/**C172** |
| Air Content of Freshly Mixed Concrete by the Pressure Method | T-152/**C231** |
| Air Content of Freshly Mixed Concrete by the Volumetric Method | T-196/**C173** |
| Time of Setting of Concrete Mixtures by Penetration Resistance | T-197/**C403** |
| Capping Cylindrical Concrete Specimens | T-231/**C617** |
| Density of Plastic and Hardened Portland Cement Concrete In-Place by Nuclear Methods | T-271/**C1040** |
| Temperature of Freshly Mixed Portland Cement Concrete | T-309/**C1064** |
| Ball Penetration | **C360** |

**Hardened Concrete for Strength**

| | |
|---|---|
| Compressive Strength of Cylindrical Concrete Specimens | T-22/**C39** |
| Obtaining and Testing Drilled Cores and Sawed Beams of Concrete | T-24/**C42** |
| Flexural Strength of Concrete (Using Simple Beam with Third-Point Loading) | T-97/**C78** |
| Compressive Strength of Concrete Using Portions of Beams Broken in Flexure | T-140/**C116** |
| Comparing Concrete on the Basis of the Bond Developed with Reinforcing Steel | T-159/**C234** |
| Flexural Strength of Concrete (Using Simple Beam with Center-Point Loading) | T-177/**C293** |
| Splitting Tensile Strength of Cylindrical Concrete Specimens | T-198/**C496** |
| Developing Early-Age Compression Test Values and Projecting Later-Age Strengths | T-276/**C918** |
| Test Method for Compressive Strength of Lightweight Insulating Concrete | **C495** |
| Test Method of Making, Accelerated Curing, and Testing of Concrete Compression Test Specimens | **C684** |
| Test Method for Compressive Strength of Concrete Cylinders Cast in Place | **C873** |
| Cylindrical Molds | |
| Test Method for Pullout Strength of Hardened Concrete | **C900** |
| Practice for Estimating Concrete Strength by the Maturity Method | **C1074** |

| | |
|---|---|
| Test Method for the Break-Off Number of Concrete | **C1150** |
| Practice for Use of Unbonded Caps in Determination of Compressive Strength of Hardened Concrete Cylinders | **C1231** |
| Molds for Forming Concrete Test Cylinders Vertically | **C470** |
| Capping Cylindrical Specimens | **C617** |

**Hardened Concrete for Other than Strength**

| | |
|---|---|
| Measuring Length of Drilled Concrete Cores | T-148/**C174** |
| Length Change of Hardened Hydraulic Cement Mortar and Concrete | T-160/**C157** |
| Resistance of Concrete to Rapid Freezing and Thawing | T-161/**C666** |
| Cement Content of Hardened Hydraulic Cement Concrete | T-178/**C1084** |
| Electrical Indication of Concrete's Ability to Resist Chloride Ion Penetration | T-277/**C1202** |
| Test Method for Fundamental Transverse, Longitudinal, and Torsional Frequencies of Concrete Specimens | **C215** |
| Test Method for Length Change of Drilled or Sawed Specimens of Hydraulic-Cement Mortar and Concrete | **C341** |
| Test Method for Abrasion Resistance of Concrete by Sandblasting | **C418** |
| Test Method for Microscopical Determination of Parameters of the Air-Void System in Hardened Concrete | **C457** |
| Test Method for Static Modulus of Elasticity and Poisson's Ratio of Concrete in Compression | **C469** |
| Test Method for Creep of Concrete in Compression | **C512** |
| Test Method for Unit Weight of Structural Lightweight Concrete | **C567** |
| Test Method for Pulse Velocity Through Concrete | **C597** |
| Test Method for Specific Gravity, Absorption and Voids in Hardened Concrete | **C642** |
| Test Method for Critical Dilation of Concrete Specimens Subjected to Freezing | **C671** |
| Test Method for Scaling Resistance of Concrete Surfaces Exposed to Deicing Chemicals | **C672** |
| Test Method for Abrasion Resistance of Horizontal Concrete Surfaces | **C779** |
| Test Method for Determining the Mechanical Properties of Hardened Concrete Under Triaxial Loads | **C801** |
| Test Method for Penetration Resistance of Hardened Concrete | **C803** |
| Test Method for Rebound Number of Hardened Concrete | **C805** |
| Practice for Examination and Sampling of Hardened Concrete in Con struction | **C823** |
| Practice for Petrographic Examination of Hardened Concrete | **C856** |
| Test Method for Half-Cell Potentials of Uncoated Reinforcing Steel in Concrete | **C876** |
| Test Method for Abrasion Resistance of Concrete or Mortar Surfaces by the Rotating-Cutter Method | **C944** |

| | |
|---|---|
| Density of Concrete by Nuclear Method | **C1040** |
| Cement Content of Freshly Mixed Concrete | **C1078** |
| Water Content of Freshly Mixed Concrete | **C1079** |
| Portland Cement Content of Hardened Concrete | **C1084** |
| Test Method for Acid-Soluble Chloride in Mortar and Concrete | **C1152** |
| Determining Consistency and Density | **C1170** |
| Making Roller-Compacted Concrete | **C1176** |
| Test Method for Water-Soluble Chloride in Mortar and Concrete | **C1218** |
| P-Wave Speed | **C1383** |
| Residual Strength | **C1399** |
| Bond Strength | **C1404** |
| Soundness by Freezing and Thawing of Concrete | CDR-C114 |
| Air-Entraining Admixtures for Concrete | |

HYDRAULIC CEMENT Test Methods

**Physical Tests**

| | |
|---|---|
| Fineness - Wagner Turbidimeter | T98/**C115** |
| Compressive Strength | T106/**C109** |
| Autoclave Expansion | T107/**C151** |
| Normal Consistency | T129/**C187** |
| Vicat Time of Setting | T131/**C191** |
| Air Content | T137/**C185** |
| Fineness - Air Permeability | T153/**C204** |
| Gillmore Time of Setting | T154/**C266** |
| Mechanical Mixing | T162/**C305** |
| Early Stiffening (False Set) | T186/**C451** |
| Fineness - No. 325 Sieve | T192/**C430** |
| Water Retention | **C91** |

**Chemical Tests**

| | |
|---|---|
| Silicon Dioxide ($SiO_2$) | T105/**C114** |
| Aluminum Oxide ($Al_2O_3$) | T105/**C114** |
| Ferric Oxide ($Fe_2O_3$) | T105/**C114** |
| Calcium Oxide (CaO) | T105/**C114** |
| Magnesium Oxide (MgO) | T105/**C114** |
| Sulfur Trioxide ($SO_3$) | T105/**C114** |
| Loss on Ignition (LOI) | T105/**C114** |
| Sodium Oxide ($Na_2O$) | T105/**C114** |
| Potassium Oxide ($K_2O$) | T105/**C114** |
| Titanium Dioxide ($TiO_2$) | T105/**C114** |
| Phosphorous Pentoxide ($P_2O_5$) | T105/**C114** |
| Zinc Oxide (ZnO) | T105/**C114** |
| Manganic Oxide ($Mn_2O_3$) | T105/**C114** |
| Sulfide Sulfur (S) | T105/**C114** |
| Chloride (Cl) | T105/**C114** |
| Insoluble Residue (IR) | T105/**C114** |
| Free Calcium Oxide ($C_a$) | T105/**C114** |
| Water-Soluble Alkali ($Alk_{sol}$) | T105/**C114** |
| Chloroform - Soluble ($Chl_{sol}$) | T105/**C114** |

ROCK Test Methods

| | |
|---|---|
| Triaxial Compressive Strength, Undrained w/o Pore Pressures | **D2664** |
| Pulse Velocity and Ultrasonic Elastic Constants | **D2845** |
| Direct Tensile Strength of Intact Rock Core | **D2936** |
| Unconfined Compressive Strength | **D2938** |
| Modulus of Elasticity (Static) in Uniaxial Compression | **D3148** |
| Tensile Strength, Splitting (Brazilian) Method | **D3967** |
| Rock Bolt Anchor Pull Test | **D4435** |
| Preparing Rock Core Specimens and Determining Tolerances | **D4543** |
| Slake Durability of Shales and Weak Rocks | **D4644** |
| Durability of Rock to Freezing and Thawing | **D5312** |
| Durability of Rock to Wetting and Drying | **D5313** |
| Laboratory direct Shear Tests on Rock Under Constant Normal Force | **D5607** |
| Point Load Index | **D5731** |
| Rock-Mass Classification for Engineering Purposes | **D5878** |
| Resistance of Rock to Freezing and Thawing | CRD-C144 |
| Expansive Breakdown on Soaking in Ethylene Glycol | CRD-C148 |
| Resistance of Rock to Wetting and Drying | CRD-C169 |

METAL Test Methods

**Zinc-Coated Steel Wire Rope and Fittings for Highway Guardrail**

| | |
|---|---|
| Ductility of Steel (Wrap Test) | M30 |
| Adherence of Coating | M30 |
| Mass of Zinc Coating | T65/**A90** |
| Tensile Strength | T244/**A370** |

**Steel Wire, Plain, for Concrete Reinforcement**
**Steel Wire, Deformed, for Concrete Reinforcement**

| | |
|---|---|
| Tension Test | T244/**A370** |
| Bend Test | M32 |

**Steel Welded Wire Fabric, Plain, for Concrete Reinforcement**
**Steel Welded Wire Fabric, Deformed, for Concrete Reinforcement**

| | |
|---|---|
| Tensile Strength | T244/**A370** |
| Bend Test | M32/**A82** |
| Weld Shear Test | M55/**A185** |

**Gray Iron Castings**

| | |
|---|---|
| Tensile Strength | T68/**E8** |
| Flexure Test | M105 |

**Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products**

| | |
|---|---|
| Adhesion of Coating | M111/**A123** |
| Thickness of Zinc Coating | M111/**A123** |

**High-Strength Bolts for Structural Steel Joints**

| | |
|---|---|
| Brinell Hardness | **F606** |
| Rockwell Hardness | **F606** |
| Tensile Strength | **F606** |
| Proof Load Determination | **F606** |
| Rotational Capacity | **F606** |

**Structural Steel**

| | |
|---|---|
| Charpy V-Notch | T266/**E23** |
| Tension Test | T68/**E8** |
| Bend Test | T244/**A370** |

**Steel Strand, Uncoated Seven-Wire for Concrete Reinforcement**

| | |
|---|---|
| Tensile Strength | T244/**A370** |
| Low Relaxation Strand | **E328** |

**Epoxy Coated Reinforcing Bars**

| | |
|---|---|
| Film Thickness | **G12** |
| Continuity of Coating (Holidays) | **G62** |
| Adhesion of Coating (Bend Test) | M284/**A775** |

PLASTIC PIPE Test Methods

**Corrugated Polyethylene Drainage Pipe**

| | |
|---|---|
| Pipe Stiffness | **D2412** |
| Pipe Flattening | M252 |
| Elongation | M252 |

**ABS and PVC Composite Sewer Piping**

| | |
|---|---|
| Stiffness and Deflection | **D2412** |

**Class PS46 PVC Pipe**

| | |
|---|---|
| Impact Resistance | **D2444** |
| Pipe Stiffness | **D2412** |
| Pipe Flattening | M278 |

**Corrugated Polyethylene Pipe, 300 to 1200-mm (12 to 48-in.) Diameter**

| | |
|---|---|
| Pipe Stiffness | **D2412** |
| Pipe Flattening | M294 |
| Brittleness | **D2444** |

MASONRY Test Methods

| | |
|---|---|
| Compressive Strength of Hydraulic Cement Mortar | T106/**C109** |
| Mechanical Mixing of Hydraulic Cement Pastes and Mortars of Plastic Consistency | T162/**C305** |
| Air Content of Hydraulic Cement Mortar | T137/**C185** |
| Use of Apparatus for the Determination of Length Change of Hardened Cement Paste, Mortar, and Concrete | M210/**C490** |
| Sampling and Testing Brick and Structural Tile Clay | C67 |
| Sampling and Testing Concrete Masonry Units and Related Units | C140 |
| Preconstruction and Construction Evaluation of Mortars for Plain and Reinforced Unit Masonry | C780 |
| Sampling and Testing Grout | C1019 |
| Compressive Strength of Masonry Prisms | C1314 |

## Appendix C: Equipment for Verification Checks

Several of the checklists for construction materials tests require assessors to perform verification checks of laboratory equipment. The following list includes recommended equipment for performing those checks. This list is not considered mandatory or exhaustive. The Accreditation Body is responsible for ensuring that the appropriate equipment is used for each verification, and that it is appropriately calibrated.

### Dimensional Equipment

Angle gauge (90± ½ °) for cube molds
45° with 2 ½ - in. circumference gauge (for flexure apparatus)
Bar mold height/width gauge
Bar mold length gauge
Calipers – Inside, outside; various sizes
Dividers (for measuring gauge length)
Feeler gauges
Feeler wires (for mechanical mixer)
Gage blocks - for flow table, verification of dimensional hand tools
Micrometers – Inside, outside; various sizes
Protractor
Pocket optical comparator (7X)
Rulers (scales)
Squares with level (6" & 12")
Tampering rod gauge
Telescoping gauges (0.5", 2")

### Mechanical Equipment

Charpy Samples
Durometers (A, D)
Glass Plate (12" x 12")
Hardness blocks (Rockwell, Brinell)
Hoke valve
Load cells Masses

- Assorted set (Class S)
- Set of 4 2000g weights, 2 1000g, 2 500g, Class S
- Set of tolerance weights for unit weight scales

Resilience Tester
Spherometer
Stopwatch
Tachometer
Tee mount for gauges
Torque wrench (50 foot pounds capacity)
Vacuum Gauge and accessories
Vibration tester

**Temperature/Thermodynamic Equipment**

Barometer
Brass Wells (3)
Motorized psychrometer
Sling psychrometer
Sling thermometers
Thermometers – Autoclave, 110° C, 150° C

**Electrical**

Microammeter test set
Pair of leads with alligator clips